DIVISION OF STRUCTURES AND ENGINEERING SERVICES
TRANSPORTATION LABORATORY
RESEARCH REPORT

CURING COMPOUNDS FOR PORTLAND CEMENT CONCRETE

FINAL REPORT

CA-DOT-TL-5149-2-76-63

Prepared in Cooperation with the U.S. Department of Transportation,
Federal Highway Administration

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

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16. ABSTRACT

New concrete curing compound formulations were developed which have properties superior to the wax- or wax-resin base materials formerly used. The new compounds are made from chlorinated rubber or hydrocarbon resin.

Two new test methods were also developed and have been adopted. In the water retention test, curing compounds can now be accepted after 24 hours of testing in lieu of the 72 hours formerly required. The second test method describes a means of measuring the spread rate of curing compounds. Alternate test methods to the two which were adopted are also described; however, further study would be necessary before implementation.

Specifications and test methods are included in the appendix.

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DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES & ENGINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

December 1976

FHWA No. F-4-13(1)
TL No. 635149A

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information this final research project report titled:

CURING COMPOUNDS FOR PORTLAND CEMENT CONCRETE

Study made by . . . . Roadbed & Concrete Branch

Under the Supervision of . . . . D. L. Spellman

Principal Investigator . . . . J. H. Woodstrom

Co-Investigator . . . . C. R. Sundquist

Report Prepared by . . . . B. F. Neal

Very truly yours,

George A Hill

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

BFN:cb

ACKNOWLEDGEMENTS

The contents of this report reflect the views of the Transportation Laboratory which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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INTRODUCTION

One of the most important factors affecting the performance of portland cement concrete is the cure it receives. Curing is basically necessary to maintain adequate moisture and temperature conditions for cement hydration during a specified period following placement. Probably the best curing method possible is a constant supply of water provided by fog spray, wet mats, ponding, etc. Since this method is not practical or economical for large areas such as pavements, liquid membrane-forming compounds have been accepted as providing adequate cure. Incorporation of white or gray pigments into the compounds provide a heat reflectance, helping to keep the concrete cool. Pigments are also an aid in determining coverage of an area by visual observations.

At the beginning of the research reported herein curing compounds used in California were normally wax or wax/resin base formulations. These were often found to be non-uniform and difficult to maintain in a thoroughly mixed solution. It was also noted that on the deeper broom textured surfaces the compounds tended to sag or run off the peaks and collect in the grooves.

The objectives of this study were to develop specifications to provide more satisfactory compounds and improved test methods to measure performance of the compounds.

CONCLUSIONS

Based on the research reported herein the following conclusions are considered warranted.

1. The hydrocarbon resin and chlorinated rubber base curing compounds have superior characteristics to the wax or wax/resin base products. Both have good moisture retention properties, are easier to keep mixed, provide good coverage even on the high points of deep textured concrete and result in a tougher film which is better able to withstand early construction traffic without tearing.

2. Determination of acceptability of water retention effectiveness of a curing compound can be made in 24 hours in lieu of the 72 hours specified in AASHTO Specification M-148.

3. Spread rates of curing compounds can be measured in the field using an absorbent pad test method more accurately than the volume per measured distance method. The pad test method can also show non-uniform distribution of the liquid membrane.

IMPLEMENTATION

The findings from the research reported here were implemented as they were developed. New curing compound formulations with improved properties are now required by the Standard Specifications. The test method formerly used for measuring water retention effectiveness was modified so that acceptance decisions can be made in 24 hours rather than the 72 hours once required. A test method for determining spread rates of curing compounds was developed and is now available for use by job inspectors.

Alternate test methods of measuring water retention properties and spread rates were found which, while appearing feasible, would have to be studied further before implementation.

DEVELOPMENT OF CURING COMPOUNDS

In a search for improved compounds, numerous commercial and laboratory formulations were tested. Out of all these, the one considered best overall was a commercial chlorinated rubber compound which was being marketed as a curing product to improve durability of concrete surface textures. The product conformed basically to Federal Specification TT-C-00800. Two other formulations, one with a limed tall oil base and the other using a petroleum hydrocarbon resin base, were also considered superior to the wax base type. All have good moisture retention properties, are easy to keep mixed, provide good coverage even on the high points of deep textured concrete, and result in a tougher film which is better able to withstand early construction traffic.

Because of the relatively high cost of the commercial chlorinated rubber products, laboratory formulations of modified chlorinated rubber type compounds were developed which not only retained the desirable physical properties but were also significantly lower in cost. Because of good drying and scuff resistance qualities this compound is particularly suited to bridge deck curing. Typically, there is much construction activity on decks as soon as the concrete is hard enough to walk on and the chlorinated rubber type seal provides a tough membrane which can take considerable "traffic" without undue damage.

Since development of the compounds, a number of changes in formulations have been necessary because of reduced availability of certain raw materials. However, it has been possible to find adequate substitutes to maintain the desired qualities. Our present specifications now list four compound formulations (see Appendix A) for use on various types of concrete work.
These are:

1. No. 721-80-71, a pigmented petroleum hydrocarbon resin base compound recommended for general use including pavements, curbs, gutters and sidewalks.

2. No. 721-80-100, a pigmented chlorinated rubber base compound recommended for use on bridge decks and structures where rapid drying and resistance to abrasion during the concrete curing period are important considerations.

3. No. 721-80-101, a pigmented (white or tinted) chlorinated rubber base compound recommended for median barriers and other vertical surfaces where it is desirable to use the compound both for curing and as a durable aesthetic coating.

4. No. 722-80-102, a clear chlorinated rubber compound, recommended for median barriers, colored concrete and other surfaces where aesthetic considerations preclude the use of pigmented compounds.

Other research on curing compounds has been directed toward reducing costs, improving resistance to yellowing, and developing water base products. Since the pigment in the chlorinated rubber formulation No. 721-80-100 is relatively pure titanium dioxide, partial substitution with various extender pigments was tried in an effort to lower pigment costs without reducing hiding power. Extenders which were tried included calcium silicate, mica, talc, and clays. Water retention tests, however, were adversely affected by partial replacement of titanium dioxide with any of the extender pigments. It was found that the use of talc as a substitute for mica in the petroleum hydrocarbon resin compound was satisfactory. No significant adverse effect on reflectance, settling or water retention was produced by the substitution.

In an attempt to reduce yellowing under weathering (which has been objectionable on median barrier applications), several ultra violet absorbers and anti-oxidants were tried in chlorinated rubber formulations. The inhibitors tested produced no significant reduction in yellowing. Formulations with acrylics and other resins have also been studied. A styrene-acrylate formulation showed less yellowing than chlorinated rubber, but it had poor water retention characteristics and cost nearly as much for raw materials as the chlorinated rubber compound. To date, no satisfactory non-yellowing curing compound has been formulated.

Because of cost and the increasingly stringent air pollution control regulations controlling the use of organic solvents, attempts have been made to develop water base curing compounds. One commercial product containing linseed oil was found to meet all specified requirements except drying time. Initial drying time, or set to touch, exceeded 6 hours, which is considered unacceptable for most uses. To date, all laboratory water base formulations with linseed oil, petroleum hydrocarbon resin, latex or acrylics, have failed to meet water retention requirements.

TESTS OF CURING COMPOUNDS

Compound Effectiveness

At the beginning of the study, curing compounds were required to meet the provisions of AASHO (AASHTO) specifications and test methods. Certain test features and test limits of the AASHTO Specifications required modification. The most important test of a curing compound involves determination of its ability to retain moisture in a mortar sample. This requires three 6 x 12 inch test specimens which must be cured in a 100°F oven for 72 hours. During a heavy construction season this often meant a full oven, and a backlog of samples waiting to be tested. Paving had been completed on some projects before it was determined whether or not the job sampled curing compound met specifications. Obviously, some method of accelerating the testing procedure was desirable, as well as other changes.

Experiments were conducted using a hotter oven (110°F and 130°F). Tests were also made on specimens of about 1/4 the specified surface area. Neither of these procedures produced satisfactory results.

From examination of considerable historic data, it was determined that two 6 x 12 inch specimens would provide results as satisfactorily as three. This change provided a significant reduction in the total number of specimens being tested at one time. It was also determined that at early ages water loss with time is approximately linear, and 24 hour results could be used to estimate the 72 hour loss.

Since the AASHTO limit on water loss was considered excessive (0.055 gr/cm^2 or approximately 25 grams per specimen), this was also reduced. The change was to a maximum loss of 18 grams of moisture in 72 hours, or 6 grams in 24 hours. A compound can be <u>accepted</u> if the 24 hour requirement is met but is not <u>rejected</u> if it fails. In the event the 24 hour loss is greater than 6 grams, the test is extended to 72 hours. These changes have resulted in a considerable increase in testing efficiency and now allow testing all samples without undue delay. The new test procedure is described in Test Method No. Calif. 534 (see Appendix B).

A number of alternate methods of measuring curing compound efficiency were investigated. Humidity buttons or gages recently developed were considered as a substitute method of measuring waster loss, but were found not to have sufficient accuracy. Another method involved the use of 2-inch mortar cubes. The cubes were cured, coated with curing compound, then dried, and weight losses determined. Others were cured, dried, coated with curing compound then placed in water or on wet mats and the amount of absorbed water was measured at intervals. The correlation between these tests and the standard test was not very satisfactory. In addition, unless the cubes were fabricated in advance, testing time was too long. Some compressive strength and abrasion tests were also tried and abandoned.

The only alternate method investigated which showed promise was a vapor transmission test. The equipment required is relatively simple, consisting of 6 inch diameter by 6 inch deep containers for water, and sharkskin filter paper. A special clamping device and a sealant prevent vapor pressure leakage. By spraying the desired amount of curing compound on filter paper which is clamped in place above the water level, the water loss, determined by weight, is that lost by vapor transmission through the curing seal. During test, the specimens are stored in a 100°F oven.

Considerable effort was expended in developing a suitable clamping device and finding the desirable sealant and filter paper. The use of this method would produce a significant savings in manpower and materials since fabrication of mortar specimens would be eliminated. Although there is concern by some who believe it is necessary for the curing compound to be in contact with the alkaline mortar, the proposed method is deemed worthy of further study.

Table 1 shows the results of several series of tests as well as results of the mortar pan test on the same compounds. See Appendix C for test method.

Table 1

Average Water Loss at 24 Hours, Grams

Curing Seal Sample No.	Mortar Method	Vapor Transmission Method	
		Water Loss	Based on Equivalent Area
CR-1	10	5.2	15.7
CR-2	6	3.4	10.3
CR-3	41	15.2	46
CR-4	21	12.2	37
Resin-1	15	3.5	10.6

Note: Only the CR-2 compound met California Specifications.

Spread Rate Determination

The most common method of determining the spread rate of curing compound on concrete pavements is by measuring the volume used over some specific area and calculating average coverage in square feet per gallon. This method, of course, does not measure uniformity of coverage nor reflect the amount of compound lost due to wind or by overspray. Although the curing rig spray nozzles are required to be shielded, there are often wind conditions that greatly reduce effectiveness of the shields. To provide a better measure of the compound being applied to pavement surfaces, a test method was needed.

Using a method (TM No. Calif. 339) for determining spread rates of bituminous distributors as a guide, Test Method No. Calif. 535 was written (see Appendix D). Under this method, absorbent pads are preweighed, then placed at various points in front of the spray rig. After the sprayer passes, the pads are folded with wet sides together, placed in a plastic bag to prevent loss of weight due to evaporation, then reweighed. Knowing the area of the pad and the gain in weight, spread rate is readily calculated.

Table 2 shows the results of laboratory tests to check the accuracy of the absorbent pad method. Spread rates of curing compound in square feet per gallon were calculated by the volume method and by the test pad method.

Table 2

Volume Method	Test Pad Method
132	129
132	130
150	145
150	152
200	195
200	220
100	96

In another laboratory test, curing compound was sprayed on an 8 ft. x 18 ft. concrete slab at a rate, based on the volume method, of 200 sq. ft. per gallon. Five test pads were placed at various locations on the slab and calculated coverage rates were 160, 200, 185, 195 and 210 sq. ft. per gallon. Even though coverage looked uniform to the eye, the tests indicate there is some non-uniformity in spread rate.

The test method was then tried in the field on several concrete paving projects. Tables 3 and 4 show typical results of tests made during two days on one project.

Table 3

Spread Rate, Sq. Ft. Per Gal.

by Volume Method	by Test Pads
123*	310
	310
	240
	165
	235
	235
	225

*Entire day's paving.

Table 4

Spread Rate, Sq. Ft. Per Gal.

by Volume Method	by Test Pads
128	165
98	170
134	195
120	175
-	165

It can be seen that uniformity was much improved on the second day, perhaps due to the fact that it was known that the previous days' rate was so variable. Also, the coverage rate calculated from the test pads is not as heavy as shown by the volume method, but is believed to be more indicative of the amount of compound actually being placed on the pavement surface. No doubt some solvent is lost through evaporation before the compound hits the pavement. This absorbent pad test method was adopted and is included in California Specifications.

Another method of measuring spread rate was also investigated. This involves a gage used in paint inspection to measure the thickness of a wet film collected on a flat rigid base. Metal or glass plates were first used, but later one gallon paint can lids were substituted and appeared to work satisfactorily. Development of the gage also required experimentation. The first gage was machined to read only to the nearest 0.002 inch and was not sufficiently accurate. The final gage was divided into 0.0005 inch segments. A tentative test method is included as Appendix E. No scales or absorbent pads are needed and the method provides a rough check to the inspector with little field work and little field equipment.

Table 5 shows results of laboratory tests in which 4-inch x 4-inch glass plates were sprayed with curing compound. Coverage rates were calculated both by the volume method and the wet film thickness method.

Table 5

Type of Compound	Test No.	Amt. of Compound Grams	Calculated Coverage, ft^2/gal.	Wet Film Thickness, Mils*	Calculated Coverage, ft^2/gal.
Resin	1.	2.8	150	11.1	145
	2.	2.3	180	8.3	195
	3.	2.05	200	7.0	230
	4.	1.65	250	6.45	250
	5.	1.4	300	5.9	275
	6.	1.2	350	5.6	290
	7.	3.1	130	12.0	130
	8.	1.6	260	7.5	225
	9.	1.5	280	6.0	270
	10.	0.9	460	4.0	415
Chlorinated Rubber	1.	3.0	150	9.7	165
	2.	2.2	200	7.9	205
	3.	1.75	250	5.85	275
	4.	1.5	300	4.97	320
	5.	1.25	350	3.85	420
	6.	1.1	400	3.5	460
	7.	2.7	160	10.5	160
	8.	1.3	340	4.5	360
	9.	1.0	450	4.0	405
	10.	0.7	640	2.5	640

*Average of 10 readings.

Encouraged by the results of the laboratory tests, the wet film method was tried in the field on four paving projects with results compared to companion absorbent pad tests. On 3 of the 4 projects the wet film test indicated 24 to 26% better coverage. Which method is more correct is not known. In converting from grams per 16 sq. inches to sq. ft. per gallon, an error in weighing of 0.1 gram in the range of 300 sq. ft. per gallon results in a difference in spread rate of about 20 sq. ft. per gallon. In the range of 300 sq. ft. per gallon, an error in measuring film thickness of 0.1 mil would result in a difference in calculated spread of about 6 sq. ft./gal. Further study would be necessary before the wet film thickness test could be adopted.

90-7 CURING CONCRETE

90-7.01B Curing Compound Method.—Surfaces of the concrete which are exposed to the air shall be sprayed uniformly with a curing compound. The curing compound shall comply with one of the following descriptions and shall be applied at the nominal rates indicated:

(1) Pigmented Curing Compound-Petroleum Hydrocarbon Resin Base (State Specification 721-80-71), one gallon per 200 square feet.
(2) Pigmented Curing Compound-Chlorinated Rubber Base (State Specification 721-80-100), one gallon per 200 square feet.
(3) Pigmented Curing Compound-Chlorinated Rubber Base - White or Tinted (State Specification 721-80-101), one gallon per 200 square feet.
(4) Non-Pigmented Curing Compound-Chlorinated Rubber Base - Clear (State Specification 722-80-102), one gallon per 250 square feet.

At any point, the application rate shall be within $\pm$ 50 square feet per gallon of the nominal rates shown above and the average application rate shall be within $\pm$ 25 square feet per gallon of the nominal rates shown above when tested in accordance with Test Method No. Calif. 535. Runs, sags, thin areas, skips, or holidays in the applied curing compound shall be evidence that the application is not satisfactory.

The compound to be used shall be of the type specified in these specifications or the special provisions for various items of work. In the event no specific type is called for, (1), (2), or (3) as listed above may be used at the option of the Contractor.

Curing compounds shall be applied using power operated atomizing spray equipment. The power operated spraying equipment shall be equipped with an operational pressure gage and a means of controlling the pressure.

The curing compound shall be applied to the concrete following the surface finishing operation immediately after the moisture sheen begins to disappear from the surface, but before any drying shrinkage or craze cracks begin to appear. In the event of any delay in the application of curing compound which could result in any drying or cracking of the surface, application of water with an atomizing nozzle as specified in Section 90-7.01A, "Water Method," shall be started immediately and shall be continued until application of the compound is resumed or started; however, the compound shall not be applied over any resulting free standing water. Should the film of compound be damaged from any cause before the expiration of 7 days after the concrete is placed in the case of structures and 72 hours in the case of pavement, the damaged portion shall be repaired immediately with additional compound.

At the time of use, compounds containing pigments shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. A paddle shall be used to loosen all settled pigment from the bottom of the container, and a power driven agitator shall be used to disperse the pigment uniformly throughout the vehicle.

The manufacturer shall include in the curing compound the necessary additives for control of sagging, pigment settling, leveling, or other requisite qualities of a satisfactory working material. Pigmented curing compounds shall be manufactured so that the pigment does not settle badly, does not cake or thicken in the container, and does not become granular or curdled. Any settlement of pigment shall be a thoroughly wetted, soft, mushy mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sidewise manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency.

All curing compounds shall remain sprayable at temperatures above 40° F. They shall not be diluted or altered in any manner after manufacture.

Curing compounds shall conform to the requirements in Section 7-1.01K, "Air Pollution Control."

The curing compound shall be packaged in clean 55-gallon steel barrels or round 5-gallon steel containers of not thinner than 0.024-inch nominal thickness metal or shall be supplied from a suitable storage tank located at the jobsite. State Specification 721-80-101 shall be supplied in 5-gallon containers only. The containers shall comply with Department of Transportation Code of Federal Regulations, Hazardous Materials Regulations Board, Reference 49CFR. The 55-gallon barrels shall have removable lids and airtight band fasteners. Five-gallon containers shall be well sealed with ring seals and lug type crimp lids. On-site storage tanks shall be kept clean and free of all contaminants. Each tank shall have a permanent system designed to completely redisperse any settled material without introducing air or any other foreign substance.

The lining of the containers shall be of a character that will resist the solvent of the curing compound and will not permit skins to be loosened into the body of the curing compound. Containers shall be filled in a manner that will prevent skinning.

Each container shall be labeled with the manufacturer's name, State Specification number, batch number, number of gallons and date of manufacture. The label shall also warn that the curing compound containing pigment shall be well stirred before use. Precautions concerning the handling and the application of curing compound shall be shown on the label of the curing compound containers in accordance with the Construction and General Industry Safety Orders of the Division of Industrial Safety, Department of Industrial Relations, of the State of California.

All containers of curing compound shall be labeled to indicate that the contents fully comply with all rules and regulations concerning air pollution control in the State of California.

When the curing compound is shipped in tanks or tank trucks, a shipping invoice shall accompany each load. The invoice shall contain the same information as that required herein for container labels.

Curing compound will be sampled by the Engineer at the source of supply or at the jobsite, or at both locations.

If the compound has not been used within 120 days after the date of manufacture, the Engineer may require additional testing before use, to determine compliance with specifications.

All tests will be conducted in accordance with the latest test methods of the American Society for Testing and Materials, Federal Test Method Standard No. 141, and methods in use by the Transportation Laboratory.

Pigmented Curing Compound—Petroleum Hydrocarbon Resin Base (State Specification 721-80-71) shall conform to the following provisions:

Composition:

Pigment Ingredients	Lbs./100 Gals.
Titanium Dioxide, ASTM Designation: D 476, Types III or IV	60.8
Whiting[1]	88.5
Mica[2]	30.8

Vehicle Ingredients	
Petroleum Hydrocarbon Resin[3]	322.0
Mineral Spirits TT-T-291E, Type II, Grade A	343.3

Characteristics of Finished Material:

Pigment by weight, percent	20.5	Min.
Weight per gallon in pounds at 77° F.	8.3	Min.
Volatiles, by weight, percent	41.6	Max.
Viscosity at 77° F., K.U.	64	Max.
Fineness of grind, Hegman	5	Min.
Daylight Reflectance, percent (ASTM: C 309)	60	Min.
Drying Time[4]		
Set to touch, hours at 77° F.	2	Max.
Dry through, hours at 77° F.	4	Max.
Water Retention, grams net loss at 24 hours[5]	6	Max.

[1] Oil absorption (Spatula) 13.1
Surface area, square centimeters per gram 4000

Particle size distribution:

Micron Diameter	*Percent by Weight Below Indicated Size*
44 (325 mesh)	100.0
40	97.0
30 (450 mesh)	84.0
20 (625 mesh)	60.0
15	42.4
12.5	35.0
10 (1250 mesh)	30.0
7.5	24.0
5	18.0
4	15.0
3	12.0
2	8.5
1	4.0

[2] Apparent density, 14 pounds per cubic foot maximum; sieve analysis, percent retained on Nos. 140 and 325 sieves, no exact requirement other than that the curing compound must comply with all requirements; moisture, 0.5% maximum; grit, 0.5% maximum; potassium oxide equivalent 7–11%; X-ray diffraction curve shall agree with curves on file with the Transportation Laboratory for muscovite mica.

[3] Specific gravity 0.93–1.12; softening point (ASTM Designation: D 36) 200–230° F.; Color (Gardner) 13 max.; iodine number Wijs 180 Max.; acid number 0–2; saponification number 0–2. Type of resin selected must be such that viscosity of resin in mineral spirits will provide a curing compound meeting viscosity requirements.

[4] Federal Test Method Standard No. 141, Method 4061, on glass plate, except use .003 in. wet film thickness.

[5] Test Method No. Calif. 534, except that the compound shall be applied at a rate of one gallon per 250 square feet.

Pigmented Curing Compound—Chlorinated Rubber Base (State Specification 721-80-100) shall conform to the following provisions:

Composition:

Pigment Ingredients	Lbs./100 Gals.
Titanium Dioxide, ASTM Designation: D 476, Types III or IV	100.0
Vehicle Ingredients	
Chlorinated Parafin, MIL-C-429, Type II, (70% Cl_2)	66.0
Chlorinated Parafin, MIL-C-429, Type I, (43% Cl_2)	66.0
Chlorinated Rubber[1]	165.4
Ethylene Glycol Monoethyl Ether Acetate, MIL-E-7125	265.0
Mineral Spirits, TT-T-291E, Type II, Grade A	265.0
Epoxy Resin[2]	2.0

Characteristics of Finished Material:

Pigment, by weight, percent	9.7 Min.
Weight per gallon in pounds at 77° F.	9.1 Min.
Volatiles, by weight, percent	58.1 Max.
Fineness of grind, Hegman	5 Min.
Viscosity at 77° F., K U.	64 Max.
Daylight Reflectance, percent (ASTM: C 309)	60 Min.
Drying Time[3]:	
Set to touch, hours at 77° F.	2 Max.
Dry through, hours at 77° F.	4 Max.
Water Retention, grams net loss at 24 hours[4]	6 Max.

[1] Chlorine percent 65–68
Viscosity, 20% in Toluene, Centipoises at 25° C. 9–14
Specific Gravity .... 1.555 to 1.565
Index of Refraction .... 1.550 to 1.560
A 25% concentration in toluene shall show no haziness or turbidity, and when stored for one week at 77° F., shall not corrode the tin plate in a covered tin-coated can.

[2] Liquid, color 5 max. (Gardner), viscosity 100–160 poises at 25° C., epoxide equivalent 180–200.

[3] Federal Test Method Standard No. 141, Method 4061, on glass plate, except use .003 in. wet film thickness.

[4] Test Method No. Calif. 534, except that the compound shall be applied at a rate of one gallon per 300 square feet.

Pigmented Curing Compound—Chlorinated Rubber Base—White or Tinted (State Specification 721-80-101) shall conform to the following:

Classification:

This specification covers a ready-mixed, chlorinated rubber curing compound, Type I (White) or Type II (Tinted), for use on portland cement concrete median barriers, and other concrete surfaces when so specified.

Type I, White

Composition:

Pigment Ingredients	Lbs./100 Gals.
Titanium Dioxide, ASTM Designation: D 476, Type III or IV	234.2
Vehicle Ingredients	
Chlorinated Paraffin, MIL-C-429, Type I, (43% Cl_2)	61.8
Chlorinated Paraffin, MIL-C-429, Type II, (70% Cl_2)	61.8
Chlorinated Rubber[1]	154.8
Normal Butyl Acetate, TT-B-838	414.6
Toluene, TT-T-548	91.2
Epoxy Resin[2]	1.6

Characteristics of Finished Material:

Pigment, by weight, percent	21.7 Min.
Weight per gallon in pounds at 77° F.	10.1 Min.
Titanium dioxide by weight of pigment, percent	90 Min.
Volatiles, by weight, percent	50.5 Max.
Fineness of grind, Hegman	5 Min.
Viscosity at 77° F., K U	65 Max.
Reflectance (for Type I only)	75 Min.
Drying Time, on concrete:	
Set to touch, hours at 77° F.	2 Max.
Dry through, hours at 77° F.	4 Max.
Water Retention, grams net loss at 24 hours[3]	6 Max.

[1] Chlorine percent 65–68
Viscosity, 20% in Toluene, Centipoises at 25° C. 9–14
Specific Gravity .... 1.555 to 1.565
Index of Refraction .... 1.550 to 1.560
A 25% concentration in toluene shall show no haziness or turbidity, and when stored for one week at 77° F., shall not corrode the tin plate in a covered tin-coated can.

[2] Liquid, Color 5 max. (Gardner), viscosity 100–160 poises at 25° C., epoxide equivalent 180–200.

[3] Test Method No. Calif. 534, except that the compound shall be applied at a rate of one gallon per 300 square feet.

Type II, Tinted

Type II curing compound shall have the same composition and characteristics as Type I except it shall be tinted a gray color with light fast tinting pigments to match Colors No. 26559, 26595 or 26622 of Federal Standard No. 595, or such other color specified in the special provisions.

Non-Pigmented Curing Compound—Chlorinated Rubber Base—Clear (State Specification 722-80-102) shall conform to the following:

Classification:

This specification covers a clear, chlorinated rubber base curing compound for use on concrete barriers, slope paving, colored portland cement concrete or other portland cement concrete surfaces as required. If specified, the compound shall be tinted with a fugitive dye which will cause the compound to be distinguishable on the concrete surface for at least 4 hours after application, but shall become inconspicuous within 7 days after application.

Composition:

Ingredients	Lbs./100 Gals.
Chlorinated Paraffin, MIL-C-429, Type I, (43% Cl_2)	66.3
Chlorinated Paraffin, MIL-C-429, Type II, (70% Cl_2)	66.3
Chlorinated Rubber[1]	166.1
Normal Butyl Acetate, TT-B-838	444.8
Toluene, TT-T-548	97.8
Epoxy Resin[2]	1.7
Soya Lecithin	9.0

Characteristics of Finished Material:

Weight per gallon in pounds at 77° F.	8.3 Min.
Volatiles, by weight, percent	65.6 Max.
Viscosity at 77° F., K U	60 Max.
Drying Time[3]	
Set to touch, hours at 77° F.	2 Max.
Dry through, hours at 77° F.	4 Max.
Water retention, grams net loss at 24 hours[4]	6 Max.
Appearance on tin plate after drying when sprayed at 30 to 40 psi, through an atomizing nozzle.	No bubbles or pinholes

[1] Chlorine percent 65–68
Viscosity, 20% in Toluene, Centipoises at 25° C. 9–14
Specific Gravity .... 1.555 to 1.565
Index of Refraction .... 1.550 to 1.560
A 25% concentration in toluene shall show no haziness or turbidity, and when stored for one week at 77° F., shall not corrode the tin plate in a covered tin-coated can.

[2] Liquid, Color 5 max. (Gardner), viscosity 100–160 poises at 25° C., epoxide equivalent 180–200.

[3] Federal Test Method Standard No. 141, Method 4061, 0.003-inch wet film thickness on glass panel.

[4] Test Method No. Calif. 534, except that the compound shall be applied at a rate of one gallon per 300 square feet.

METHOD OF TEST FOR WATER RETENTION EFFICIENCY OF LIQUID MEMBRANE-FORMING CONCRETE CURING COMPOUNDS

Scope

This test method, which is a modification of AASHO Designation: T-155 (ASTM Designation: C-156), decribes the laboratory procedure for determining the efficiency of liquid membrane-forming curing compounds in preventing moisture loss from concrete during the early hardening period.

Procedure

A. Apparatus

1. Molds—Molds shall be rigid water-tight pans 6 x 12-inches at the top, 5¾ x 11¾-inches at the bottom, within ±¼-inch, and 2± ⅛-inch in depth on the inside. Molds shall have a flat rim at the top on all sides, approximately ¼-inch in width. It is recommended that this rim be reinforced by welding a ¼-inch rod around the outside perimeter of the pan, just beneath the rim.
2. Metal Plates—Metal plates shall be 6 x 12-inch with edges raised slightly to retain sprayed compound.
3. Curing Cabinet—The cabinet for curing the specimens shall maintain a temperature of 100±3F (37.8±1.7C) and a relative humidity of 30±4%. Air flow shall be sufficient to remove the solvent vapors quickly, but no detectable air current shall strike directly on the surface of any test specimen stored in the cabinet.

B. Materials

1. Graded Ottawa sand conforming to the requirements of ASTM Designation: C-109.
2. Portland Cement, Type II. *DO NOT USE CONCRETE ADMIXTURES OR AIR-ENTRAINING CEMENT IN THIS TEST.*

C. Preparation of Specimen Molds

Thoroughly clean the molds before each use and apply a thin coating of a suitable mold release compound.

D. Preparation of Mortar Test Specimens

Machine mix all batches of mortar at room temperature (73±3F) following the schedule given for mixing mortars in ASTM Designation: C-305.

1. Number of Test Specimens

a. The test shall consist of two specimens. Prepare each specimen from a separate batch of mortar.

2. Proportioning and Mixing Mortar

a. Trial Batch. Whenever a new lot of cement or sand is to be used, prepare a trial batch of mortar having a water-cement ratio of 0.4 with sufficient sand to produce a flow of 35±5 as measured in ASTM Designation: C-87. Use these proportions in preparing subsequent test batches.

b. Mortar for Test Specimens. Using the mix proportion determined by the trial batch, prepare sufficient mortar to fill a 12x6x2-inch pan.

3. Molding Specimens. Place the mortar in the mold in two approximately equal layers; Consolidate each layer by tamping or with a mechanical vibrator. Avoid overvibration. Strike off the excess mortar and finish the surface with a wooden screed having a flat two-inch wide screeding surface. Advance the screed along the long axis of the specimen using a circular motion. Do not work the surface more than necessary to produce a reasonably even finish.

4. Storage of Specimens

a. After molding, place the specimens in the curing cabinet in a level position. Space the specimens uniformly on the shelf with a clear space of from two to seven inches on all sides of each specimen. Use dummy specimens to replace test specimens when a shelf is not filled with test specimens.

b. Remove test specimen from the cabinet 1¼ to 1¾ hours after molding. Use a putty knife or paint scraper to form a "V" shape groove approximately ⅛-inch deep and not over $\frac{1}{16}$ inch wide between the edge of the mortar and the mold. (Mortar should be dry enough that the groove will not collapse or fill with water). Fill the groove with a sealant which will remain pliable at 100F and which is resistant to the solvents in the curing compound. Return the specimen to the cabinet for approximately ½ hour.

c. Test the mortar surface condition by rubbing a small area with the finger tip. The specimen shall be ready for brushing when rubbing produces only a few fine bubbles. Brush the entire surface of the mortar lightly in the longitudinal direction with a 2-inch flat sash tool, Morck 791-2 or quivalent. (Brushing shall be just sufficient to remove the sheen from the surface.)

E. Application of Curing Compound

1. Mortar Specimens. Immediately after brushing, weigh the mortar specimen to the nearest gram. With a suitable spray gun, and, unless otherwise specified, apply ten (10) grams of curing compound in a uniform coating on the mortar specimen. Keep overspray to a minimum. Wipe off any drops of compound which may adhere to the under surface of the rim but do not attempt to remove compound from upper surface of the rim of the pan. Determine the actual rate of application by reweighing the mortar specimen immediately after applying the curing compound.
2. Metal Plate. Weigh the metal plate to the nearest gram. Apply ten (10) grams of curing compound in the same manner used for the mortar specimen. Determine the actual rate of application by reweighing the plate immediately after applying the curing compound.

F. Testing of Treated Specimens

After applying compound and reweighing, place the mortar specimens and the metal plate in the curing cabinet. Cure for 24 hours at 100±3F and 30±4%

relative humidity. Then remove from the curing cabinet and weigh to the nearest gram.

G. Calculation

1. Calculate the total weight lost by each mortar specimen as the weight of the specimen immediately after applying the curing compound less the weight of the specimen after the 24 hour curing period.

2. Calculate the volatile loss of the curing compound in grams as the weight of the metal plate immediately after applying the compound less the weight of the plate after 24 hours in the curing cabinet.

3. Calculate the water loss in grams from each mortar specimen as the total weight lost by the specimen less the volatile loss of the curing compound.

Reporting of Results

Record all weights and calculations on Form HMR T-577. Report the results of this test on Form T-584.

REFERENCES

AASHO Designation: T-155
ASTM Designations: C-87, C-109, C-156, and C-305

End of Text on Calif. 534-A

APPENDIX C

TENTATIVE METHOD OF TEST FOR MEASURING WATER VAPOR TRANSMISSION THROUGH CONCRETE CURING SEALS

SCOPE

This test method describes the procedure for determining the efficiency of liquid membrane-forming compounds as measured by their ability to prevent water vapor transmission.

PROCEDURE

A. Apparatus

1. Balance sensitive to 0.1 gram with a capacity of 3000 grams (the Mettler Model P3 fills this requirement).

2. Suitable wind shield for balance to prevent air currents from causing errors in weighing.

3. Curing cabinet, for curing the specimens at a temperature of 100±3°F (37.8±1.7C) and a relative humidity of 30±4%. Air flow shall be sufficient to remove the solvent vapors quickly, but no detectable air current shall strike directly on the surface of any test specimen stored in the cabinet.

4. Sharkskin filter paper, 6-inch diameter.

5. Tube GE Clear Silicone Seal.

6. One 500-ml graduated cylinder.

7. Cylindrical plastic containers, 6-inch in diameter (OD) 6-inch deep, with a 7-1/2 inch sq. x 3/8 inch thick plate firmly and permanently attached to the bottom. The cylinder walls shall be 1/4 inch thick. These containers shall be fitted with a metal clamping device (see Figure 1) and shall keep the sharkskin filter paper firmly in place to prevent vapor pressure leakage. This can be accomplished with a neoprene rubber gasket glued permanently to the top plate in a recess cut at the inner perimeter to receive the plastic cylinder. A thin coating of silicone seal on the lip of the plastic container creates a positive non-stick seal.

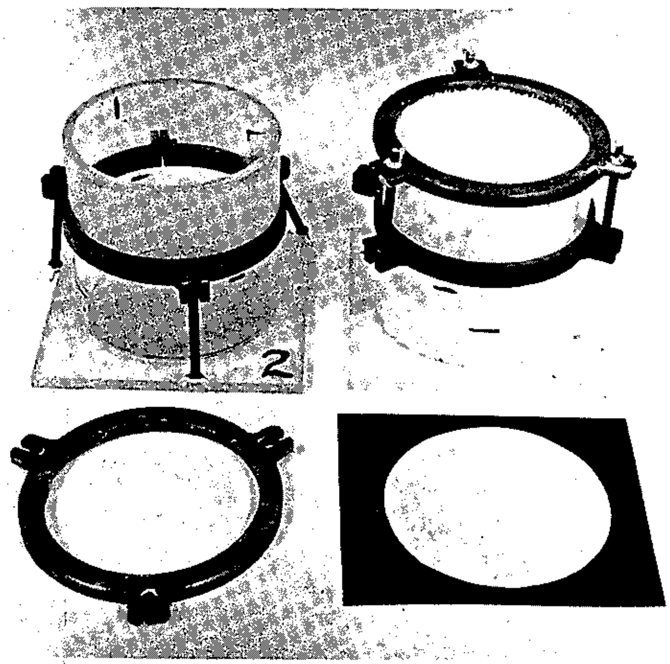

Figure 1

B. <u>Preparation of Containers for Testing</u>

1. Place 500 mls distilled water in each test container.

2. Put a thin film of silicone seal on the container, then carefully place filter paper on lip.

3. Bring cover down slowly so as not to disturb paper.

4. Place swing bolts in slots, tighten wing nuts evenly, but to a firm finger tightness.

C. <u>Application of Curing Compound</u>

1. Tare container to nearest 0.1 gram and record weight.

2. Stir sample thoroughly just before spraying, making sure there has been no settlement.

3. With a suitable spray gun and correct pressure, spray the entire exposed surface of filter paper, being careful to obtain a uniform coverage of an amount applicable to the spread rate for the curing compound being tested.

4. Reweigh and record weight of container immediately after proper coverage is sprayed on.

5. Prepare and spray three container specimens for each sample tested.

6. Spray an equal amount of compound being tested on a blank sharkskin filter paper to measure volatile loss.

D. Testing of Treated Specimens

1. After applying compound and reweighing, place the treated specimens along with the treated paper disk in curing cabinet at 100±3°F and 30±4% relative humidity for 24 hours. Remove from the curing cabinet and weigh to nearest 0.1 gram.

E. Calculation

1. The total weight lost by each specimen is the weight of the specimen immediately after applying the curing compound less the weight of the specimen after the 24-hour curing period.

2. The volatile loss of the curing compound to the nearest 0.1 gram is the weight of the filter disk immediately after applying the compound less the weight of the disk after 24 hours in the curing cabinet.

3. Calculate the water loss for each specimen to the nearest 0.1 gram as the total weight lost by the specimen less the volatile loss of the curing compound.

F. Precaution

1. Spray only under vented hood.

2. Clean spray gun thoroughly after each test.

3. Avoid prolonged breathing of compound or solvents used to clean spray gun.

State of California
Department of Public Works
Division of Highways

MATERIALS AND RESEARCH DEPARTMENT

Test Method No. Calif. 535-B

April 7, 1969
(2 pages)

METHOD OF TEST FOR DETERMINING APPLICATION RATE OF CONCRETE CURING COMPOUND IN THE FIELD

Scope

This test method, an adaptation from Test Method No. Calif. 339, describes the procedure for determining the rate at which concrete curing compound is applied to portland cement concrete pavements.

Procedure

A. Apparatus

1. Balance, accurate to 0.5 gram, or less, and having a capacity of about 200 grams.
2. Suitable weighing box or wind shield for balance.
3. Stop Watch
4. Specific gravity bottle (25 to 100 ml. capacity), or hydrometer (range about 0.90 to 1.10 specific gravity).

B. Materials

1. Disposable diapers, absorbent pad with waterproof backing, 12½" x 16" (Daytime Pampers, Procter and Gamble or equal).
2. Plastic sheet, .040" thick by 11" x 15". This may be cut from sheet plastic, Template material, cellulose acetate, Division of Highways Service and Supply No. 17246.
3. Sack-plastic polyethylene 9" x 15", 100 per pkg. with ties, Division of Highways Service and Supply No. 69663.

C. Preparation of Test Pads

1. Form test pad by trimming edges of waterproof backing to match dimensions of absorbent pad. (Do not detach pad from backing). Discard trimmings.
2. Weigh each test pad together with a plastic sack to the nearest gram, to establish tare weight.
3. Insert 11" x 15" plastic sheet between absorbent pad and backing in order to keep pad flat and prevent its being blown aside or turned over by wind or spray.

D. Sampling and Weighing

1. Longitudinal Distribution. Place 5 test pads, with absorbent face up, along the pavement approximately 3 feet from the edge at random intervals (7–13') over a 50 foot length ahead of the spray rig. (See figures I and II).
2. Transverse Distribution. Where fixed nozzles on a distributor bar are used, it is desirable to determine transverse distribution. Place 5 test pads absorbent face up, at random intervals across the slab or under nozzles which appear to be delivering at abnormal rates. Place test pads on the pavement and remove them without stepping on newly placed concrete. Observe whether the curing compound is being applied at its normal rate at the time the spray equipment passes over the test pads.
3. As soon as the spray rig has passed, remove each test pad from the pavement. Wipe off any adhering moisture, curing compound or mortar from the waterproof backing.
4. Remove plastic sheet and save for reuse. Fold absorbent pad inside its waterproof backing and place in plastic sack. Tie opening of bag firmly to prevent loss of volatiles. Complete this operation within two minutes after application of curing compound to the test pad.
5. Weigh each test pad in its plastic bag as quickly as possible to the nearest gram. (Consider the test invalid unless the weighing operation is completed within one hour after removing the test specimen from the pavement.) Record as "final weight."

E. Calculations

1. Calculate the total weight of curing compound applied to each test pad as the final weight less the tare weight. Read the nominal application rate in square feet per gallon from Table I. Calculate the actual rate of application, (corrected for specific gravity of compound if different from 1.00), by multiplying the rate from Table I by the specific gravity of a well mixed representative sample of the curing compound. (If possible, this sample should be taken from a spray nozzle or from the feed line to the spray nozzle. The specific gravity shall be determined by means of a suitable pycnometer or hydrometer.)
2. Calculate the average application rate in square feet per gallon, as the sum of the individual corrected rates divided by five.

F. Notes and Precautions

1. Weigh the wet test pads as soon as possible to reduce errors caused by loss of volatiles.
2. By means of a stop watch, time the rate of advance of the spray equipment over several fifty foot sections to establish the average time of travel for fifty feet. Then check the time taken to spray the test section by the same method to determine if the spray equipment operator maintains the same forward speed. Similarly, read the pressure gauge on the spray equipment during normal operation and when compound is applied to the test section. If the time of travel or pressure varies more than 10% from the average, consider the tests invalid and repeat the test.
3. Shield test pads placed near the edge of the pavement slab from overspray from nozzles applying compound to the exposed edge of slip-formed pavement.
4. A test pad may be placed at some distance from the edge of the pavement and later removed by using a pole or lath.

REFERENCES

Test Method No. Calif. 339

End of Text on Test Method No. Calif. 535-B

TABLE I

CONVERSION TABLE

Net Weight of Curing Compound on 12½" x 16" Test Pads to square feet per Gallon

Net Weight of Curing Compund on Test Pads, Grams	Nominal Appl. Rate, Square Feet per Gallon	Net Weight of Curing Compound on Test Pads, Grams	Nominal Appl. Rate, Square Feet per Gallon
10	504	30	168
11	458	31	163
12	420	32	158
13	388	33	153
14	360	34	148
15	336	35	144
16	315	36	140
17	296	37	136
18	280	38	133
19	265	39	129
20	252	40	126
21	240	41	123
22	229	42	120
23	219	43	117
24	210	44	115
25	202	45	112
26	194	46	110
27	187	47	107
28	180	48	105
29	174	49	103
		50	101

Approximate Rate of Application-Sq.ft/gal, based on actual measured test pad area 12" x 16" (nominal 12½" x 16") assuming a specific gravity for curing compound of 1.00. For specific gravity different from 1.00, multiply "application rate" from Table, times the actual specific gravity of the compound.

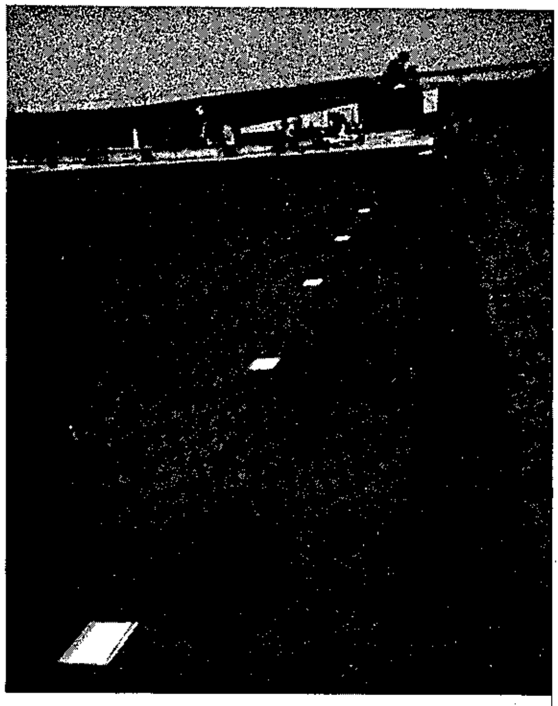

FIGURE II

Test Pads in Position for Test

FIGURE I

Placing Test Pads on Pavement

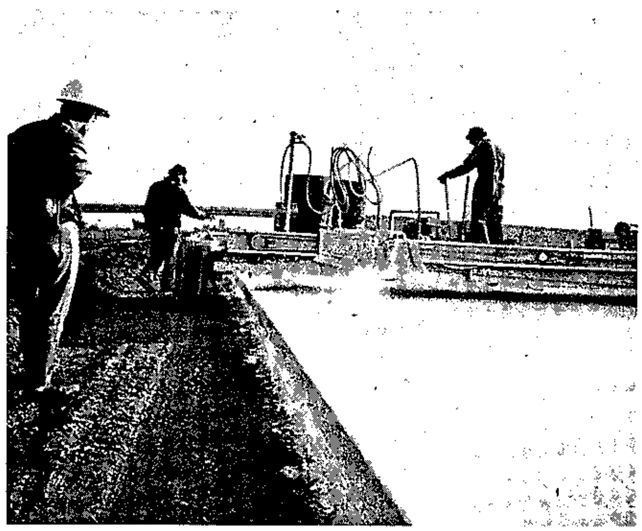

FIGURE III

Spray Equipment Passing Over Test Pads

APPENDIX E

TENTATIVE METHOD OF TEST FOR DETERMINING SPREAD RATE OF CURING COMPOUNDS BY WET FILM THICKNESS TEST

SCOPE

This test method describes the procedure for determining the spread rate of curing compounds in the field as measured by the wet film thickness of curing seals.

The thickness gage used in this procedure reads to the nearest 0.5 mil. Through precalculated charts, gage reading is directly converted to indicate coverage in square feet per gallon.

PROCEDURE

A. Apparatus

1. Gallon paint can lids, heavy duty T.P. 51, E-Z Pry.

2. 6-inch by 6-inch smooth finish thin steel plates. Plates are used with a magnet to retrieve paint can lids without disturbing curing compound

3. 1/2-inch by 1-inch by 6-inch magnet with sufficient magnetic attraction to pick up and firmly hold paint can lid and the 6" x 6" steel plate. Attach wires near ends of magnet to form "handle" for use in retrieval of paint can lid.

4. A 5/8-inch by 60-inch round dowel with cup hook screwed into one end, to hook into wire "handle" on magnet.

5. 2-inch by 2-inch by 1/8-inch stainless steel gage that is graduated to read from 0.5 mils to 12.0 mils in 0.5 mil increments.

6. One red 1-gallon can to store supply of toluene or other solvent that will cut curing compound being used.

7. 1 quart can to hold solvent for cleaning gage after test.

8. Disposable medical gloves (vinyl).

9. Supply of rags for cleaning.

B. Preparation for Testing

1. When pavement finishing is completed, carefully place paint can lids on surface. Place 3 test lids in a random pattern transversely over a 50 foot length of pavement ahead of the curing rig. Use a long survey marker or other stick to place the lids beyond arms reach to prevent stepping on fresh concrete.

2. Have dowel, with cup hook attached to wire that holds magnet, and 6-inch plate near by so that lid can be retrieved immediately after spray rig passes over. Bring magnet and steel plate down evenly to insure that curing compound on lid is not disturbed and that the lid is not tilted when contact is made.

C. Testing Sprayed Lid

1. Hold as evenly as possible to insure that curing compound will not run to one side.

2. Grasping bottom of lid firmly with one hand, slide top plate off being careful not to disturb sprayed surface.

3. Holding lid as level as possible with one hand, press down evenly but firmly with other hand (do not allow gage to slide). The last marker that shows white or when using clear, the last marker that shows wet, will be the correct reading. Wipe compound from gage on a rag immediately after each reading. Take and average five readings as the film thickness. These five readings should be taken within 60 seconds after retrieval.

D. <u>Calculation</u>

1. Repeat determination of film thickness as outlined in "C" on other lids in this test section. Calculate the average film thickness for all lids in the test section for use in determining coverage rate.

2. Use precalculated coverage conversion chart to read the indicated coverage that is directly opposite the average gage reading.

E. <u>Precautions</u>

1. Use vinyl plastic gloves.

2. Clean gage after each reading by wiping quickly across cloth rag.

3. Clean gage thoroughly with solvent after each test, as a slight amount of buildup of residue can adversely affect the next test.

4. Avoid breathing of strong solvents.

WET FILM THICKNESS TEST
COVERAGE INDICATOR CHART

Wet Film Gage Readings	Coverage Sq.Ft./Gal.	Wet Film Gage Readings	Coverage Sq.Ft./Gal.
3.90	420	6.00	270
3.95	410	6.20	260
4.05	400	6.50	250
4.15	390	6.70	240
4.30	380	7.00	230
4.40	370	7.50	223
4.50	360	8.00	207
4.60	350	8.50	190
4.80	340	9.00	180
4.90	330	9.50	170
5.00	320	10.00	160
5.20	310	10.50	155
5.40	300	11.00	147
5.50	295	11.50	144
5.60	290	12.00	136
5.80	280		